The Monogem Ring: A Nearby SNR Similar to the Local Bubble ?

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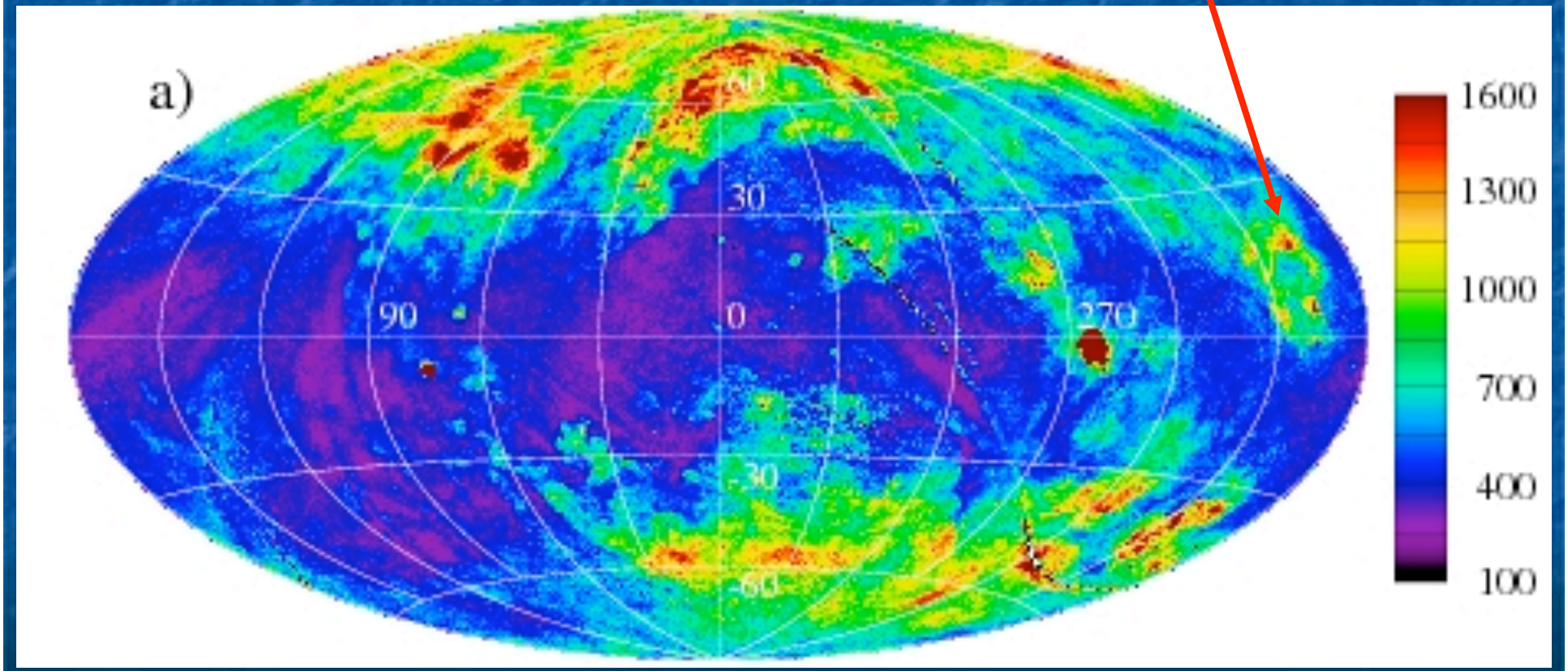
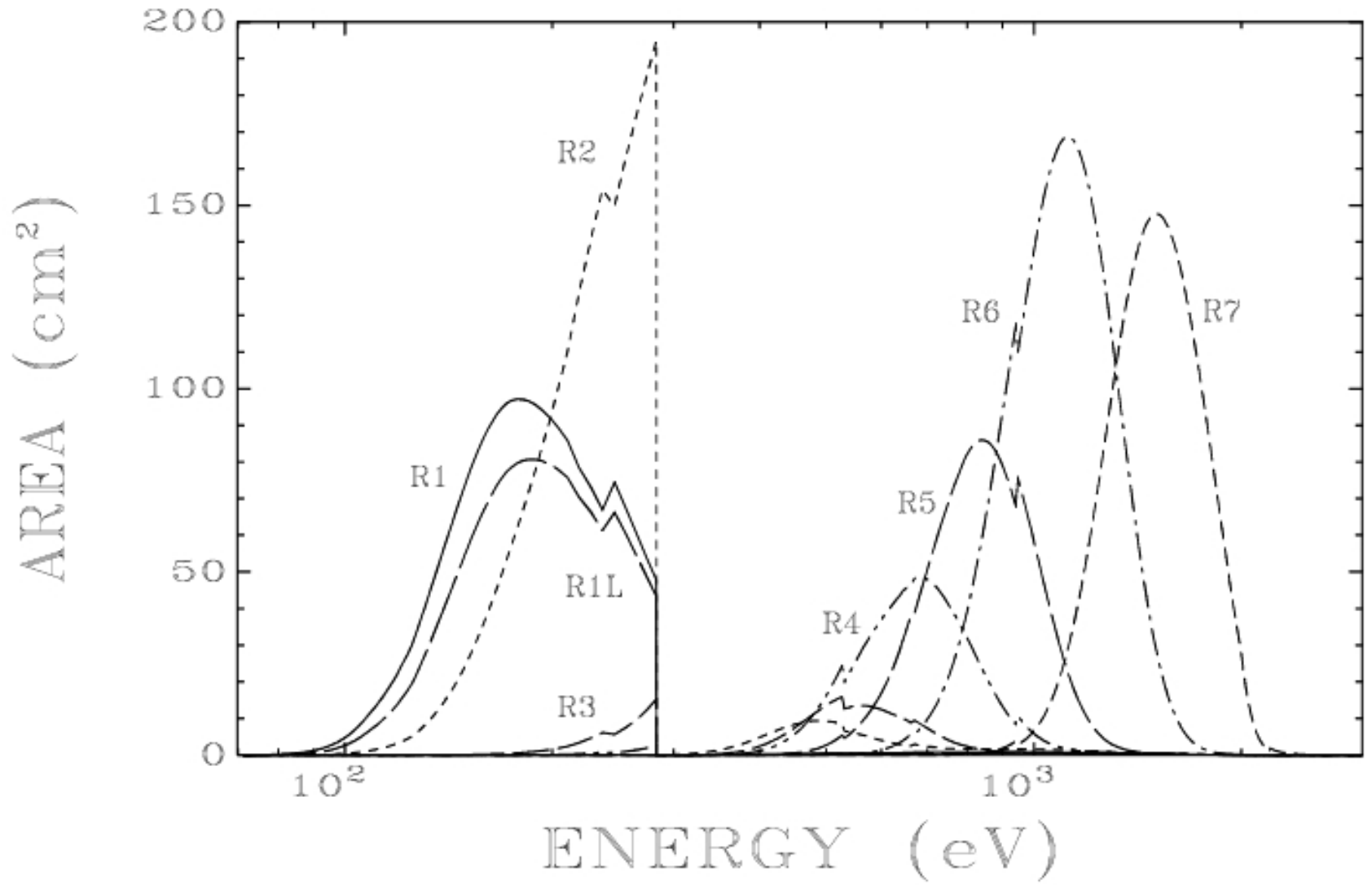
What is the Monogem Ring ?

- ROSAT All-Sky Survey, R1+R2 Band, Snowden *et al.* 1997
- large region of enhanced emission in the Galactic anticenter



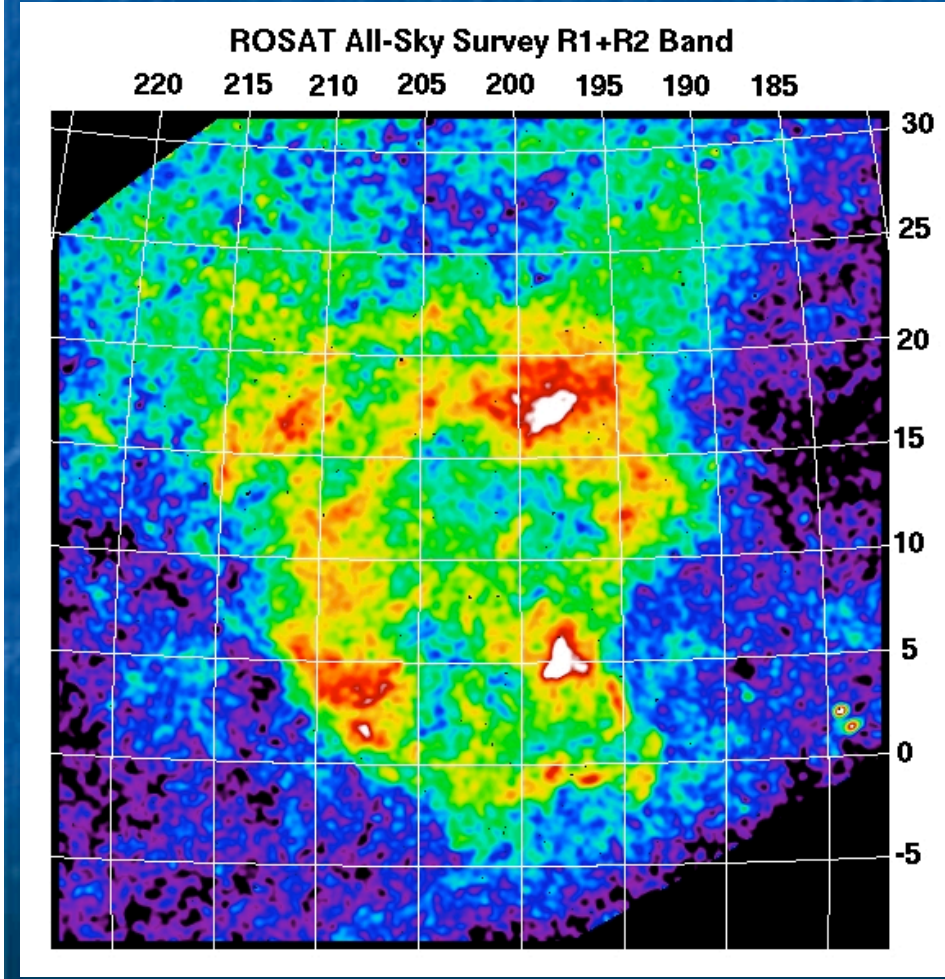
RASS R1-R7 Band Definitions

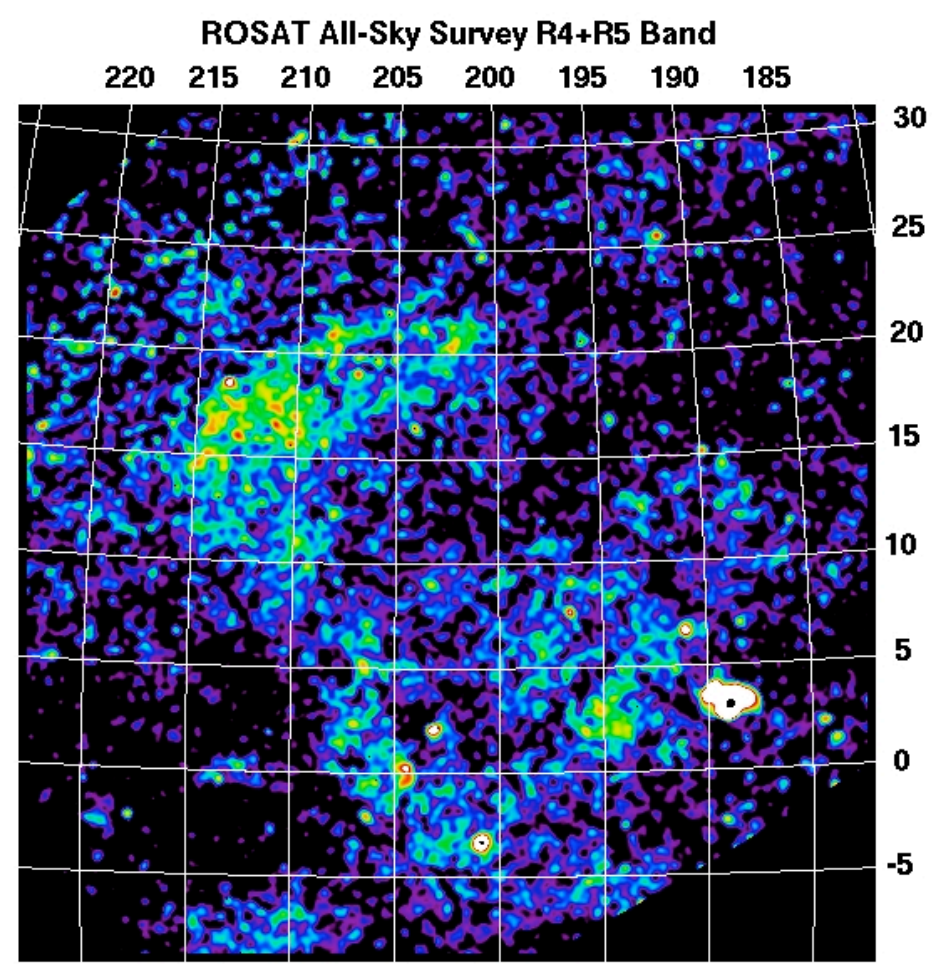
- Snowden *et al.* 1997, R1+R2~C band, R4+R5~M band



Monogem Ring: RASS R1+R2 & R4+R5 Band Images

- ring of soft X-ray emission with radius ~12.5 degrees, located at (l,b)~(203,+12)
- little evidence for absorption in the Galactic plane





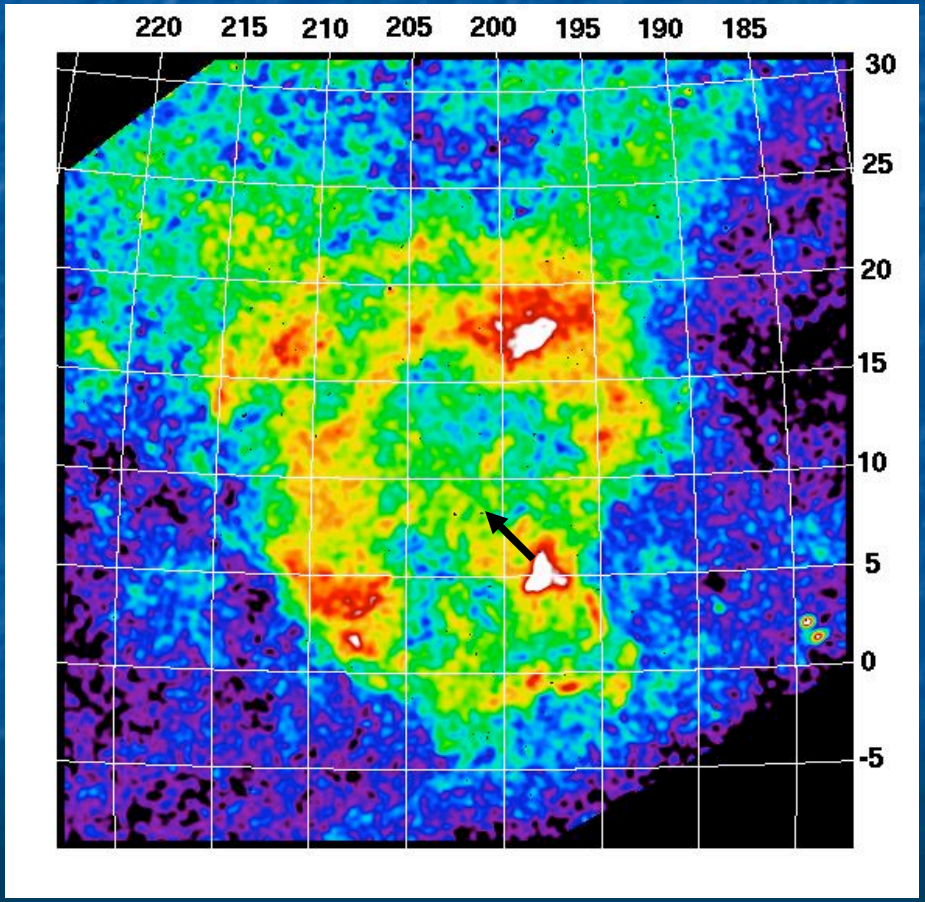
SNR Models: Plucinsky *et al.* 1996

- assume remnant is in the adiabatic phase, assume $N_H = 5.0 \times 10^{19}$ cm^{-2}
- assume CIE model for emission (Raymond & Smith 1977)

D (pc)	R (pc)	n_o (10^{-3} cm^{-3})	Age (10^4 yr)	ε_o (10^{51} ergs)	P_{th}/k (10^3 K cm^{-3})	M_x ($M_\odot$)
100	22.2	9.0	2.9	0.01	78.5	12.5
300	66.5	5.2	8.6	0.19	45.3	195.3
600	133.0	3.7	17.1	1.10	32.0	1104
1000	221.7	2.9	28.5	3.93	24.8	3961
1300	288.2	2.5	37.1	7.58	21.8	7633

Association with PSR 0656+14

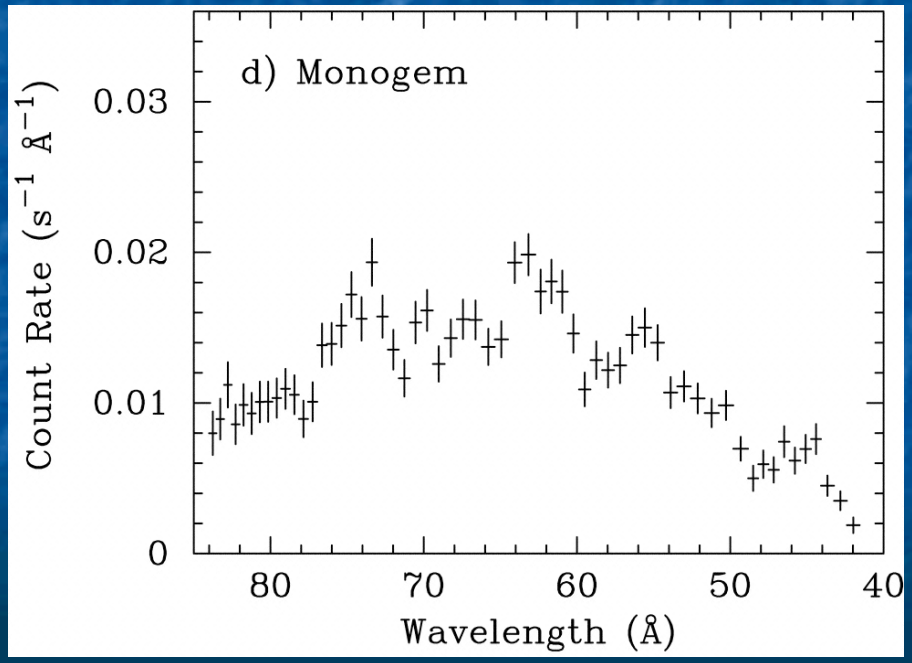
- radio pulsar with a characteristic age of $\tau = 1.1 \times 10^5$ yr
- located near center of X-ray ring, proper motion show pulsar is moving away from the Galactic plane (Thomspon & Cordova 1994, Pavlov *et al.* 1996, Mignani *et al.* 2000)
- parallax measurement by Brisken et al. 2003 determines distance to be D=288+/- 30 pc
- Chandra LETG (Marshall & Schulz 2002) spectrum determines $N_H = 1.7 \times 10^{20} cm^{-2}$
- Thorsett et al. 2003 conclude that the association is firm



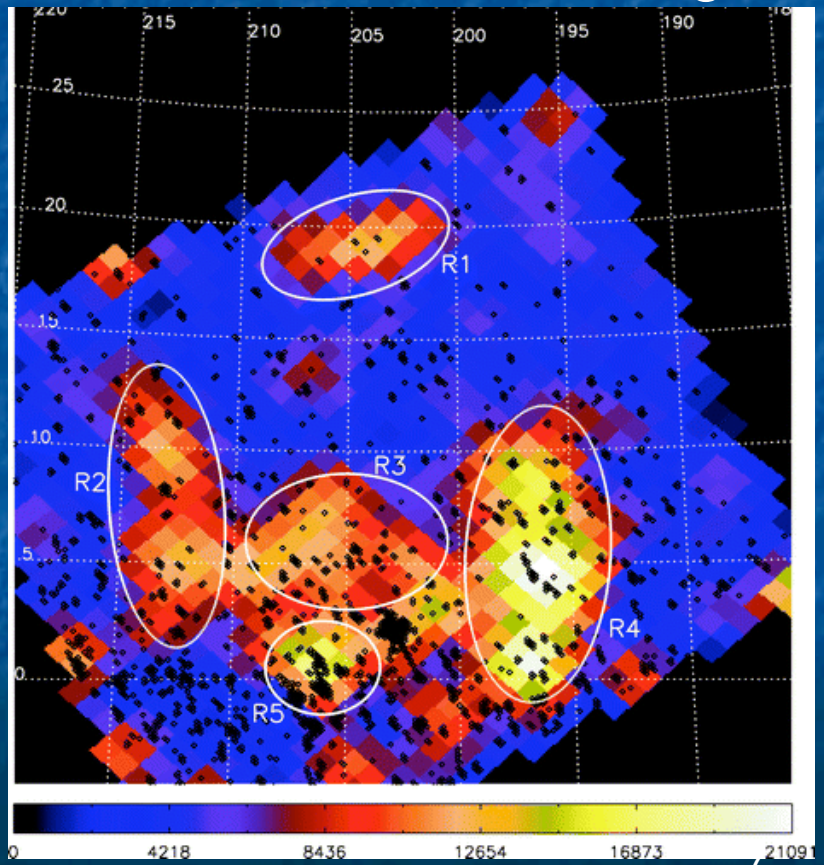
High Spectral Resolution X-ray and FUV Observations

- DXS (Sanders *et al*. 2001, Edgar poster this conference) provided highest resolution spectrum of the Monogem Ring, consistent with low N_H
- SPEAR (Kim *et al*. 2007) provides first FUV image of Monogem Ring , also consistent with low N_H

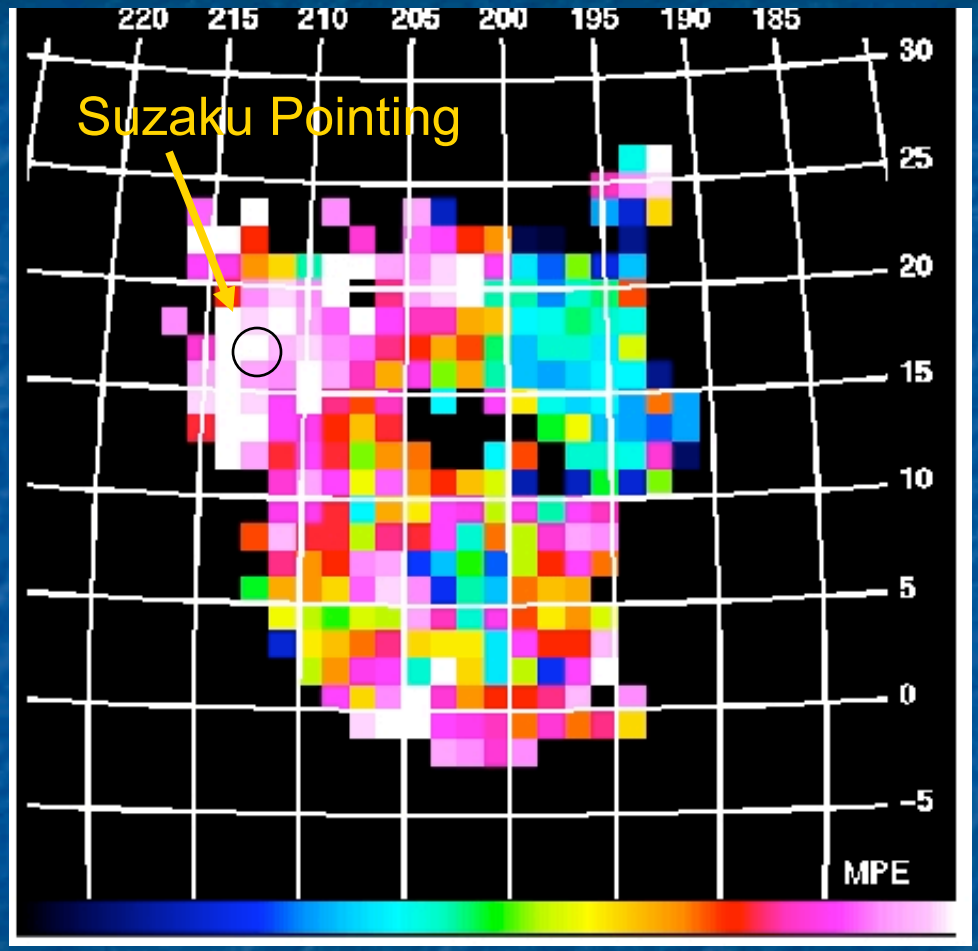
DXS Spectrum 148-284 eV



FIMS/SPEAR C IV Image



Temperature Distribution of the Monogem

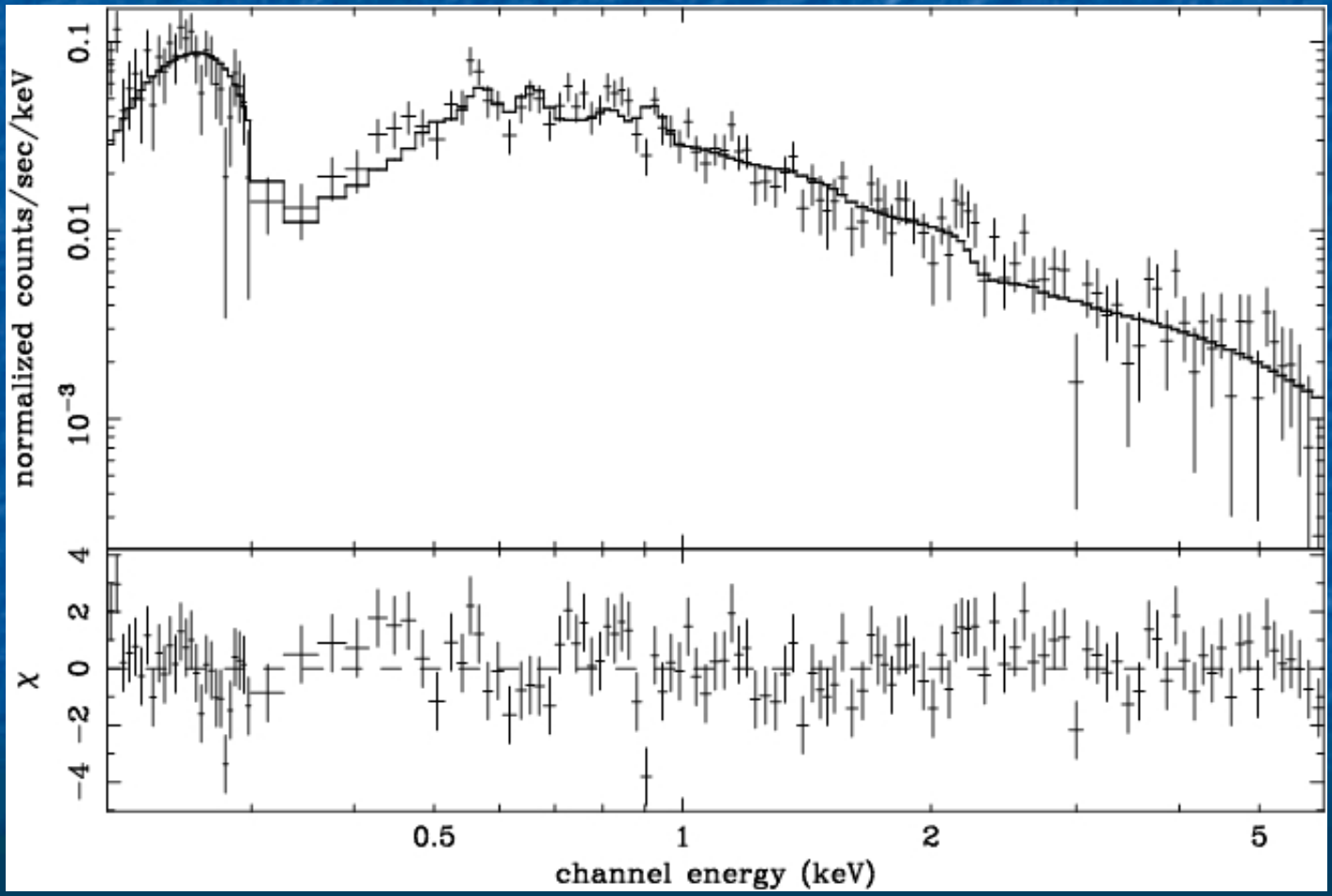


- temperature calculated in 1.28X1.28 degree regions
- temperature distribution based on CIE model (Raymond & Smith 1977), DXS data indicate a more complicated model is needed
- propose 50 ks Suzaku observation at highest temperature region

$5.8 < \log(T/K) < 6.3$

Suzaku XIS1(BI CCD) Spectrum

- tbabs(vapec) + tbabs(pow), kT=0.20 keV, O abundance =0.5 x solar
- Reduced chi=1.3, DOF=130



Comparison to Local Bubble

- Adopt a D~300 pc for the Monogem and associated model
- Local Bubble model is multiple SNe separated by 1 Myr (Smith & Cox 2001)

	Monogem	LB
n_o (cm^{-3})	0.0052	0.2-0.4
Age (10^6 yr)	0.086	3-6
ε_o (10^{51} ergs)	0.2	2-3
P_{th}/k (10^3 K cm^{-3})	4.5	1.0-1.8

* Numbers for LB model will change if some of the emission is attributed to SWCX

Conclusions

- If one accepts the association with PSR 0656+14, the Monogem Ring is a nearby bubble of hot gas, D~300 pc
- The Monogem Ring appears to be a younger, less-energetic explosion into a lower ambient density medium than the Local Bubble
- high spectral resolution observations with adequate angular resolution are needed to properly characterize the conditions in the plasma of the Monogem Ring